DOOSAN Document Transmittal

Upper Trishuli 1 HEP (216MW)

Date	DT No.:	SHEET
2022-03-25	UT1-HEP-DHI-PC-D-0015	1 OF 1

DOOSAN NEPAL BRANCH OFFICE	Address & Contact No. : Four Square Building, Naxal, Kathmandu, Nepal (P.O Box : 1387) + 977 1 692 3014	Project No. H20002	DOCUMENT DISPATCHED BY Courier Service ☐ Messenger ☐ Post-Air Freight ☐ Document System or E-mail ■ By hand ■
DOCUMENT DISTRIBUTION	■ POWER CHINA (Subcontractor) ☐ Doosan's Site Office		
SUBJECT	Review Note RN-0093 Slope Stability Calculation of Left Bank Dam Area		

S. N.	REVIEW NOTE NO.	REVIEW STATUS	DWG. / DOC. NO.	REV.	DWG. TITLE / DOC. DESCRIPTION	REMARK
1	RN-0093	RR	UT1-C-050-CVL-DC-44002	0B	Slope Stability Calculation of Left Bank Dam Area	
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Received by :

Date :

Legend of Review Status
A : APPROVED
AN : APPROVED AS NOTED
RR : RETURN FOR RESUBMISSION
FI : FOR INFORMATION

DHI STAMP

Doosan Heavy Industries & Construction Co. Ltd. DOOSAN Branch Office Nepal

Issued by DHI

Youngsoo Son

Project Manager

Email: youngsoo.son@doosan.com
Doosan Heavy Industries & Construction Co., Ltd.

Discipline : Civil

UPPER TRISHULI-1 HEP (216MW)

Client	**Nepal Water and Energy Development Company Private Limited**
Owner's Engineer	**Tractebel Engineering GmbH / Jade Consult**

REVIEW NOTE

Contractor	**Doosan Heavy Industries & Construction Co., Ltd.**		
Title of the Document	Slope Stability Calculations of Left Bank Dam Area		
Document No.	UT1-C-050-CVL-DC-44002	Revision	0B
Date of Documents	03.02.2022	Received Date	03.02.2022
Transmittal Form No.	UT1-HEP-DHI-D-0171		
Previous Review Date/Status	01.03.2022/FI	Prev. Review Note No.	RN-0068
Review Note No.	**RN-0093**	**Present Review Date**	**24.03.2022**
		Present Review Status	**RR**

A: Approved AN: Approved as Noted RR: Returned for Resubmission FI: For Information, only

Following the requirements of NWEDC, OE has discussed the document directly with DHI during the design meeting at site of 14.03.2022. OE has advised DHI to revise the document and resubmit it.

However, during the design kick-off meeting on 22. March 2022, DHI has insisted on the correctness of the assumptions and calculation results presented in the report. Consequently, the undersigned was requested to conduct a thorough design review, which is presented herewith.

General: **The document shows in several aspects inappropriateness in geomechanical design,** resulting in erroneous and misleading outcomes. In the following only two of these issues are highlighted that show the complete inappropriateness of the design of the cut slope. These refer to:

- Wrongly – i.e. through wrong back-calculations - determined geomechanical input data were used in the calculations.
- Wrongly conducted slope stability calculations for support design.

This review made it evident that the author of the document is unaware how back-calculations and slope stability calculation are conducted correctly.

Therefore, and for clarification, in the following the undersigned is firstly demonstrating how the conducted analyses should have been done correctly; afterwards the errors in the conducted slope support design are highlighted. This refers to both:

- **back-calculations of geomechanical parameters**
- **slope stability calculations**

Wrongly determined geomechanical input data were used in the calculations

In Tab. 3.2.1 of the report the geomechanical parameters for the encountered soils are listed as follows:

Table 3.2-1 Physical and mechanical indexes of dam foundation overburden

Alluvial type	Density(g/cm^3)	Internal friction angle (°)	Cohesive strength (kPa)
Colluvial deluvium pluvial deposits	2.1～2.2	35.0	30
Pluvial and alluvial deposits	2.1～2.2	32.0～37.0	0～15

Note: The median values are adopted for calculation.

This data refers to (in Chapter 2.2 provided reference (2)) to document UT1-C-855-CVL-DD-40502, dated 20.12.2022 (Supplementary Investigation Report on Engineering Geology).

Looking into this reference (=report UT1-C-855-CVL-DD-40502) one can read that the data was determine by back calculation (so-called “inversion”) for Section C.

A back-calculation of the geomechanical parameters of a soil slope is conducted correctly by:

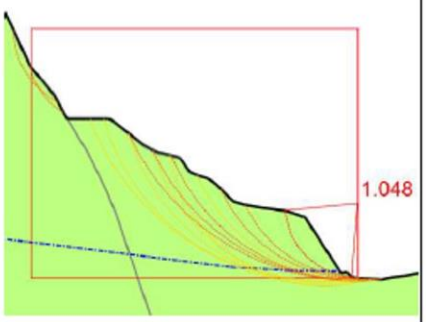
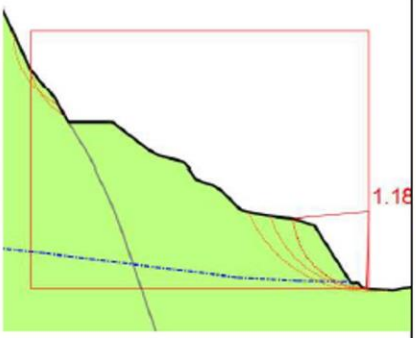
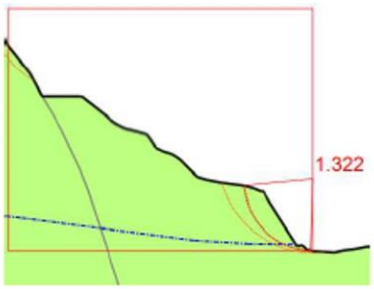
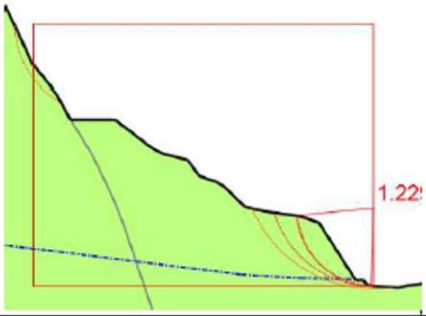
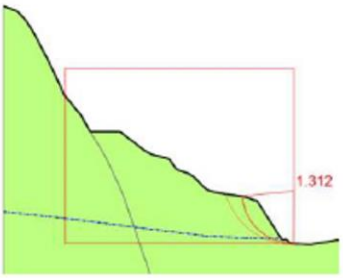
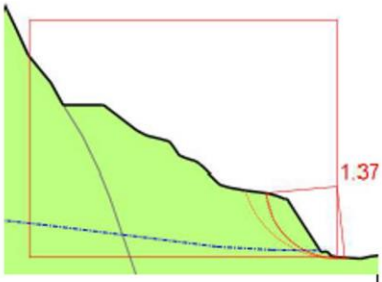
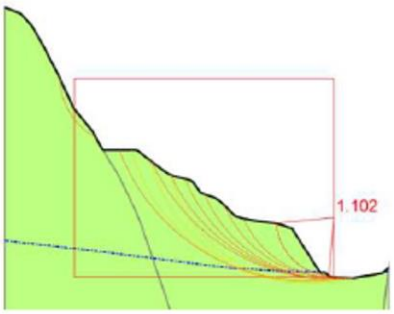
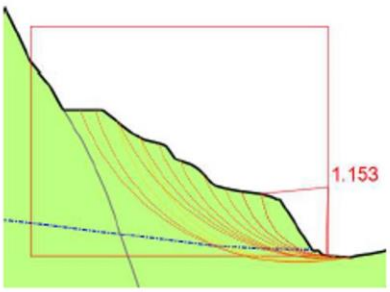
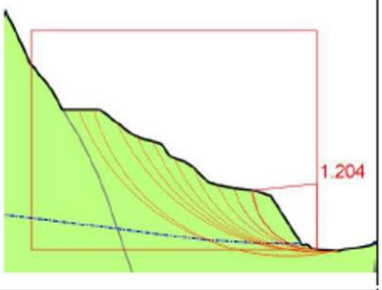
- *assuming the factor of safety F = 1.0 throughout the calculations, i.e. the slope is at limit equilibrium, but it did not fail yet.*
- *assuming worst groundwater conditions (= water table during monsoon) as the slope did not fail under these conditions.*
- *varying the geomechanical parameters ϕ and c in the calculations so that always a factor of safety of 1.0 is maintained. When c is increased, ϕ is decreased, vice versa – always maintaining F = 1.0*
- *producing a ϕ–c-diagram*
- *selecting a ϕ-c data pair, which fits best to the characteristics of the soil (e.g. select a data pair with higher cohesion and lower friction angle for fine grained materials, or select a data pair with lower cohesion and higher friction angle for coarse grained materials)*

From the figure below – taken from the referenced report - one can read, **calculations were conducted which produced – by changing the parameters ϕ and c - different factors of safety. As noted above, back calculations must be always done keeping the factor of safety at 1.0.**

Hence, the “back calculations” in report UT1-C-855-CVL-DD-40502, were conducted inappropriately/wrongly; and consequently, produced misleading results. These results were used in the slope stability calculations and support design.

In addition, in the figure below, one realises that the assumed groundwater table, which is indicated by the dashed blue line, is unrealistic for the rainy season. As noted above, in back calculations one must assume the highest (reasonable) groundwater table, which results – in back calculations - in much higher cohesion and friction angle than with a low groundwater table.

Table 1.4-15 Summary of Slope Inversions below the Road

1. C=25, φ=30°	2. C=25, φ=35°	3. C=25, φ=40°
		
Fs=1.048	Fs=1.18	Fs=1.322
4. C=30, φ=35°	5. C=30, φ=38°	6. C=30, φ=40°
		
Fs=1.229	Fs=1.312	Fs=1.371
7. C=30, φ=30°	8. C=35, φ=30°	9. C=40, φ=30°
		
Fs=1.102	Fs=1.153	Fs=1.204

Wrongly conducted slope stability calculations for support design.

Slope stability analyses in geotechnical engineering and slope support design calculations are conducted as follows:

- *Determine the potential failure surface and hence sliding body of reasonable geometry in a slope with the lowest factor of safety for the worst loading conditions.*
- *Calculate **for this sliding body** the factor of safety with respective support. Check if the support produced the required safety factor of the slope, otherwise increase support until satisfaction of the factor of safety.*

In the figure below – taken from the calculation report – one can see the determined potential sliding body with a safety factor F = 0.926. As such factor of safety is unsatisfactory one must apply support and determine the increase in the factor of safety through this support.

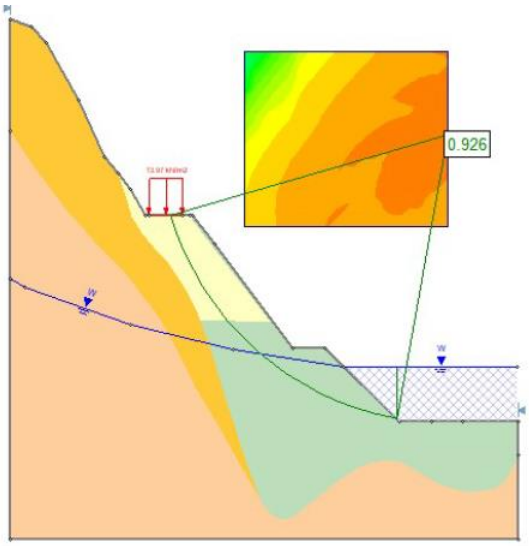


Figure 4.2-2 Safety factor of section C in case 1 after excavation (Flood P=0.5%)

The figure below one can read that support was installed. **However, the safety factor of 1.358 refers to an entirely different sliding body, but not to the identified critical sliding body.**

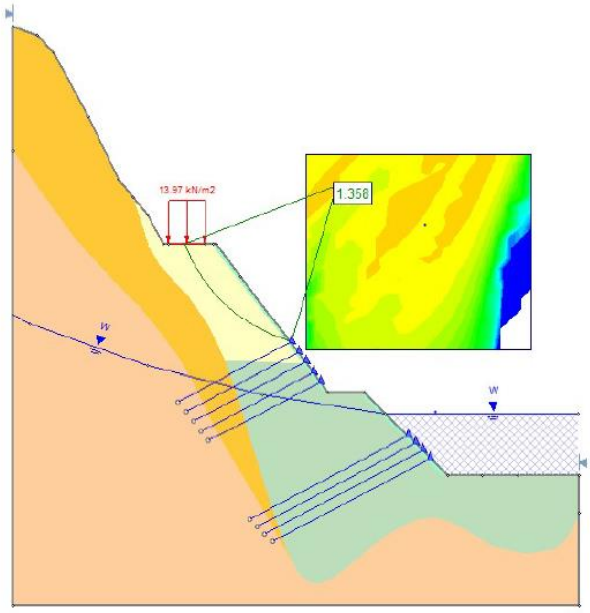


Figure 4.2-3 Safety factor of section C in case 2 after support (Flood P=0.5%)

For the above-mentioned reasons, the report is returned for correction. The determination of geomechanical parameters for the slope through back-calculation shall be conducted correctly, so shall be the slope stability analyses and the support design.

The review in hand shows also that the document UT1-C-855-CVL-DD-40502, dated 20.12.2022 (Supplementary Investigation Report on Engineering Geology), produced wrong results. Consequently, the designer is requested to resubmit this report with the respective corrections, as already informed you with our Design Review Note No. 50, dated 26.01.2022.

For information, from this Review Note No. 50 it is quoted: *"it appears that the report is self-reviewing the produced geotechnical data and even conducts design (related issues). There are many, highly sensitive design issues in this geological report addressed, such as "estimation of liquefaction potential of the dam foundation", or "factor of safety calculations for slopes", "factor of safety calculations for wedges in the rock of the Powerhouse". These issues should be addressed in the respective design reports, certainly not in a report on engineering geology."*

DISCLAIMER

Any approval will not release the Contractor from any of his obligations under the Contract.

Dr. Ulrich Glawe